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DRY-LAND GRAINS IN THE GREAT BASIN.

BY

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DRY-LAND GRAINS IN THE GREAT BASIN.[a]

INTRODUCTION.

The investigations here reported were begun July 1, 1907, at the Nephi substation, Nephi, Utah. The "Memorandum of understanding between the Utah Agricultural Experiment Station and the

In 1907 Mr. W. M. Jardine, Agronomist in the Office of Grain Investigations, was placed in direct charge of these experiments with dry-land cereals, and assistants have been detailed to look after the experiments in each locality. These investigations are conducted in cooperation with other offices of the Bureau and in some instances with state experiment stations.

The objects of the experiments may be briefly stated as follows:

(1) To bring together for comparative tests at these experimental farms large numbers of varieties of the various grain crops from all sections of the country and from foreign countries having similar climatic and soil conditions;

(2) To develop pure types from the most promising strains and varieties, through individual plant selections, from which seed can be increased for distribution among farmers, and to obtain foundation stocks for further improvement through breeding;

(3) To develop winter-resistant types in order to further extend the winter-grain area;

(4) To determine the best cultural methods, such as time, rate, and method of seeding, etc.

The accompanying paper is the first of a series on dry-land grains that will be offered for publication as the work progresses. The author of this paper, Mr. F. D. Farrell, has been in immediate charge of the work at Nephi, Utah, since July 1, 1907.

Acknowledgment is made, with thanks, to Grace Brothers and to Messrs. Peter Peterson, James Jensen, and John Q. Adams for information regarding their farm practices. Mr. Farrell is indebted to Dr. E. D. Ball, director of the Utah station, and to Prof. L. A. Merrill, agronomist in charge of arid farms, Utah station, for their permission to use some hitherto unpublished data secured at Nephi before cooperation, which have materially strengthened the discussion of several subjects. Mr. Stephen Boswell, foreman of the Nephi substation, has rendered much valuable assistance in the work, as has also Mr. S. R. Boswell.—G. H. Powell, *Acting Chief of Bureau.*

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[a] The Office of Grain Investigations, of this Bureau, has necessarily given particular attention for a number of years to experiments in the dry-land districts because of the introduction of a number of grain crops adapted to those districts. It became necessary to concentrate a large amount of this work at particular points in order to become familiar with the proper relations of these crops to others and to obtain more information concerning methods of cultivation suited for such localities, etc. Extensive experiments have, therefore, been inaugurated at the following points: Amarillo and Dalhart, Tex., Akron, Colo., and Bellefourche, S. Dak., operated as independent stations; Highmore, S. Dak., Dickinson and Williston, N. Dak., Judith Basin (Philbrook P. O.), Mont., Moro, Oreg., and Nephi, Utah, operated in cooperation with the respective state experiment stations.

Bureau of Plant Industry, U. S. Department of Agriculture" specifies that "the objects of these cooperative investigations shall be (1) to improve the cereals of the intermountain region by introducing or producing better varieties than those now grown, especially with regard to drought resistance, yield, quality, earliness, etc.; (2) to conduct such other experiments as might seem advisable for the accomplishment of the greatest possible good to the dry-land interests of the State."

Most of the experiments being conducted deal directly with the grains, but, as provided in clause 2 above mentioned, a number of tests of other crops and of various farming methods are being made. It is likely that the grains, particularly wheat, will always be the principal crop on the dry lands of the intermountain area. The policy of the cooperators, therefore, is to pursue, so far as possible, any line of investigation that is likely to increase our knowledge of the conditions under which dry-land grains can be most profitably and advantageously produced. The investigations have not been wholly confined to the experiments at the substation. The superintendent has made observations on various farms in different parts of the Mountain States, particularly in Utah, and the information thus gained is freely used in this report.

While the work has not progressed far enough to warrant the publication of positive conclusions relative to all the experiments, a considerable amount of definite information has been obtained. It is thought that this information will be of value to the farmers in the intermountain region. It is for the purpose of acquainting these farmers with the facts secured at and through the Nephi substation and with the scope and character of the experiments being conducted that this report has been prepared.

DESCRIPTION OF THE SUBSTATION.

In its agricultural conditions the Nephi substation is fairly representative of large areas of unirrigated and unirrigable lands in the Intermountain States. The results obtained at Nephi can reasonably be expected to apply broadly to the dry lands in Utah, the southern part of Idaho, sections in eastern and northern Nevada, and possibly in northern Arizona and New Mexico. A brief description of the substation's location and of its climatic and soil conditions is given here for the use of farmers in different sections of the intermountain area who wish to compare their own agricultural conditions with those under which the experiments here discussed are conducted. The more nearly the climate, soil, etc., of a given locality resemble those at the Nephi substation, the greater the likelihood that the results obtained at Nephi will apply.

LOCATION.

The substation is situated in the eastern part of Juab County, Utah. It comprises 102 acres of land on the Levan Ridge, 6 miles south of the town of Nephi, in the Juab Valley. Its elevation is approximately 6,000 feet.

RAINFALL.

The primary climatic factor in dry-land farming in the western United States is the rainfall. This is subject to wide monthly and annual variation and, particularly in the Rocky Mountain States, considerable differences are found in the quantities and distribution of the precipitation received by localities not widely separated. Table I reports the rainfall of the Juab Valley for the years 1898 to 1909, inclusive. From 1898 to 1903, inclusive, the observations were made by the United States Weather Bureau observer at Levan, 6 miles south of the substation, but since January 1, 1904, a record has been kept at the substation.

Table I.—*Precipitation (in inches) in the Juab Valley, Utah, for each month from 1898 to 1909, inclusive, with averages and maximums and minimums for each month.*

Year.	Total annual.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1898	15.67	0.80	0.25	1.45	1.06	5.57	0.90	1.62	0.73	0.00	0.99	0.94	1.36
1899	17.43	1.43	2.25	3.96	.71	1.75	.95	.25	1.06	.00	2.07	1.09	1.91
1900	10.34	.87	.70	.12	3.70	.57	.04	.03	.28	1.70	.69	1.45	.19
1901	13.31	.93	2.23	1.88	1.02	1.74	.29	.25	1.55	.18	1.31	.53	1.40
1902	12.49	.53	1.41	2.41	1.20	.16	.03	.32	.20	.91	1.62	1.98	1.72
1903	12.58	1.64	.98	1.33	2.03	2.26	.48	.47	.15	.92	1.56	.24	.52
1904	11.20	.68	1.44	2.41	.80	3.10	.02	.36	.17	.20	1.05	.00	.97
1905	12.63	.28	2.22	1.57	1.22	1.39	.21	.31	.60	3.17	.08	1.01	.57
1906	18.48	1.48	.68	3.83	2.87	2.92	.43	.80	1.57	.61	[a] T.	1.47	1.82
1907	15.43	1.90	2.01	1.42	.93	1.76	1.58	.32	1.46	.74	.84	.50	1.97
1908	16.66	.81	1.11	1.12	.29	3.64	.67	.52	3.41	2.28	1.73	.46	.62
1909	16.93	2.57	1.70	1.03	2.21	.68	.17	.95	2.84	.68	.32	1.53	2.25
Average	14.43	1.16	1.41	1.88	1.50	2.13	.48	.51	1.17	.95	1.02	1.01	1.27
Maximum	18.48	2.57	2.25	3.96	3.70	5.57	1.58	1.62	3.41	3.17	2.07	1.98	2.25
Minimum	10.34	.28	.25	.12	.29	.16	.02	.03	.15	.00	[a] T.	.00	.19

[a] T.=trace.

Table I shows that, during the twelve years, the total annual precipitation has varied from 18.48 inches in 1906 to 10.34 inches in 1900, the average annual amount being 14.43 inches; that six years have received more than the average amount and six years less than the average, and that only two of the years have received less than 12 inches.

Table I shows further the highest and the lowest amount of precipitation occurring in each month during the twelve-year period, together with the twelve-year average for each month. A very important fact shown by the table is the low rainfall of June and July.

It is during June and early July that the dry-land grains are most severely tried, and only those grains that are able to withstand the drought of this period can be successfully grown under conditions similar to those obtaining at Nephi. The month of May is the wettest of the year in the Juab Valley, its average being 2.13 inches for the past twelve years. Table I shows, however, that the precipitation of this month varies quite widely. The highest precipitation in May was 5.57 inches, in 1898, and the lowest was 0.16 inch, in 1902. Further use of Table I will be made later in the report.

SEASONAL RAINFALL.

The quantity and distribution of the rainfall during the growing season are matters of high importance in dry-land grain production. Regardless of the precipitation during other months of the year, the grain crop in the Mountain States depends very largely upon the moisture conditions prevailing during the months of April, May, and June. Hence, in judging of the agricultural possibilities of a locality and in determining upon the most desirable farming practices it is not sufficient to consider merely the total annual amount of precipitation received. The seasonal rainfall must be taken into account.

The rainfall of the growing months (April, May, and June) in the Juab Valley during the past twelve years is reported in Table II.

TABLE II.—*Precipitation (in inches) during the growing season (April, May, and June) in the Juab Valley, Utah, from 1898 to 1909, inclusive, with the average, the maximum, and the minimum for each month.*

Year.	April.	May.	June.	Total.
1898	1.06	5.59	0.90	7.53
1899	.71	1.75	.95	3.41
1900	3.70	.57	.04	4.31
1901	1.02	1.74	.29	3.05
1902	1.20	.16	.03	1.39
1903	2.03	2.26	.48	4.77
1904	.80	3.10	.02	3.92
1905	1.22	1.39	.21	2.82
1906	2.87	2.92	0.43	6.22
1907	.93	1.76	1.58	4.27
1908	.29	3.64	.67	4.60
1909	2.21	.68	.17	3.06
Average	1.59	2.13	.48	4.11
Maximum	3.70	5.57	1.58	7.53
Minimum	.29	.16	.02	1.39

It will be noticed that extremely wide variations occur in a given month from year to year. April has varied from 3.70 inches in 1900 to 0.29 inch in 1908; May, from 5.59 inches in 1898 to 0.16 inch in 1902; June, from 1.58 inches in 1907 to 0.02 inch in 1904. It is notable that June has received as much as an inch only once in twelve years. The total for the three-months period specified has varied from 7.53 inches in 1898 to 1.39 inches in 1902, the average seasonal rainfall being 4.11 inches.

EVAPORATION.

Closely connected with the rainfall as a factor in dry-land farming is the evaporation. This is determined by measuring daily the amount of water that is lost from an open cylindrical tank placed in the ground so that the surface of the water in the tank is approximately level with the surface of the ground. Where the evaporation is high the amount of water required by crops and the difficulty of conserving soil moisture are greater than where the evaporation is low. Hence the danger of loss through drought is relatively greater.

The evaporation at the Nephi substation, as determined during the seasons of 1908 and 1909, is approximately 40 inches for the six months beginning April 1. At Amarillo, Tex., for the same period it is 50 inches; at North Platte, Nebr., 42 inches; and at Edgeley, N. Dak., 28 inches.[a] Nephi has an evaporation which is about the average of the amounts determined at the various dry-land experiment stations of the West.

The amount of evaporation depends principally upon the relative dryness of the atmosphere, the amount of wind, and the temperature. When the dryness of the air or the amount of wind increases, or when the temperature rises, the evaporation is greater. The substation is now equipped with instruments for determining the amount of moisture in the atmosphere, the amount of wind, and the temperatures. The work is done in cooperation with the Physical Laboratory of the Bureau of Plant Industry, by which the equipment is furnished.

WIND.

The amount of wind was determined at the substation from April 1 to October 31, 1909. The anemometer was placed about 2 feet above the ground near the evaporation tank. This determines the amount of wind that passes directly over the water in the tank and hence the amounts that directly affect the soil. During the seven months beginning April 1 the wind recorded was 20,621.4 miles. This gives an average velocity of 4 miles an hour for the entire season. The average hourly velocity, as determined daily, varied from about 2 miles to 8 miles. This shows that the wind at the substation is not very high for any length of time. Compared with wind velocities on the Great Plains, those at Nephi are exceedingly low. They represent fairly the wind condition in the valleys of the Great Basin area.

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[a] "Physical Problems in Connection with Dry Farming," by L. J. Briggs and J. O. Belz, in Proceedings, Third Dry-Farming Congress, Cheyenne, Wyo., 1909.

TEMPERATURE.

The maximum and minimum temperatures are determined daily at the substation from April 1 to October 31. The work was not started until June 1, 1908. The highest temperature recorded in 1908 was 97.5° F. on August 4; in 1909 the maximum was 99.5° F. on July 3. In 1908 the last spring frost occurred on June 22 (30° F.) and the first autumn frost on August 30 (31° F.). This left a period of only 69 days without frost. In 1909 the last spring frost came on May 30 (30.5° F.) and the first autumn frost on September 12 (30.5° F.), leaving a period of 105 days free from frost.

SOIL.

The soil at the Nephi substation is a heavy clay loam of a red-brown color. It is of a fairly uniform texture to a depth of 6 to 8 feet, where it becomes more sandy. The high percentage of clay (approximately 15 per cent) makes the soil rather difficult to handle, particularly when it is very wet or very dry. It puddles readily and great care is necessary to prevent its becoming hard and baked. It resembles a large portion of the soils of the Great Basin area.

NATIVE VEGETATION.

One of the most reliable methods of comparing agricultural soils is to compare the vegetation found on them in their virgin condition. Hundreds of thousands of acres of arid land in the West are covered with a heavy growth of sagebrush (*Artemisia tridentata*). This was the condition at the substation at the time the land was plowed in 1903. In this respect the conditions were typical. (See Pl. I, fig. 1.)

SUMMARY.

A brief summary of the conditions at the substation, as above described, will assist the farmer in making comparisons. The elevation is 6,000 feet; the 12-year average annual rainfall is 14.43 inches; the rainfall of April, May, and June during the same period has averaged 4.11 inches; the evaporation for six months, beginning April 1, is about 40 inches; the wind velocity during the season of 1909 averaged 4 miles per hour and seldom exceeded 8 or 10 miles per hour; the highest temperature during the seasons of 1908 and 1909 was 99.5° F.; there was a 69-day period (June 22 to August 30) without frost in 1908, and a 105-day period (May 30 to September 12) without frost in 1909; the soil is a heavy clay loam, which in its virgin condition produces a heavy growth of sagebrush. The conditions at Nephi are typical of those existing over large areas in the Mountain States.

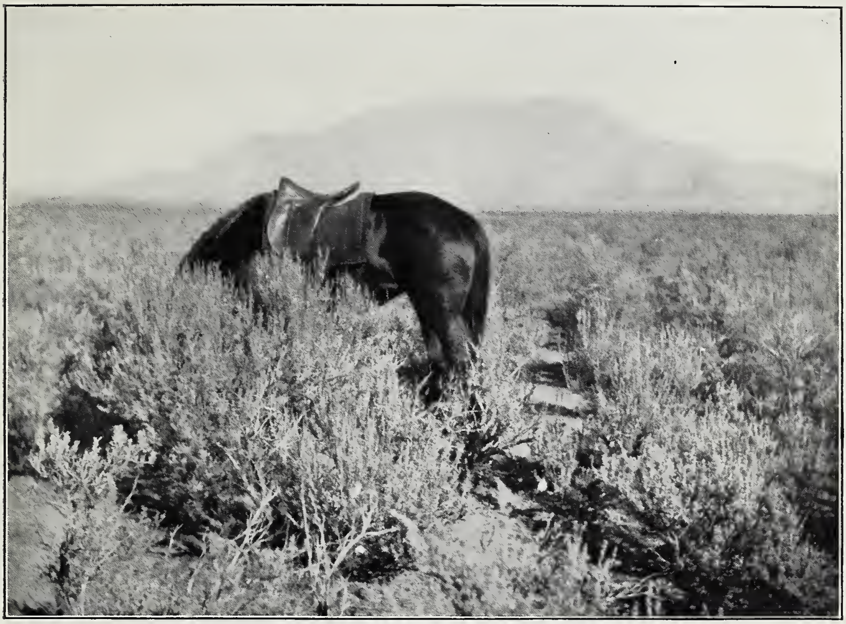

FIG. 1.—VIEW NEAR THE SUBSTATION AT NEPHI, UTAH, SHOWING SAGEBRUSH, THE PREVAILING NATIVE VEGETATION.

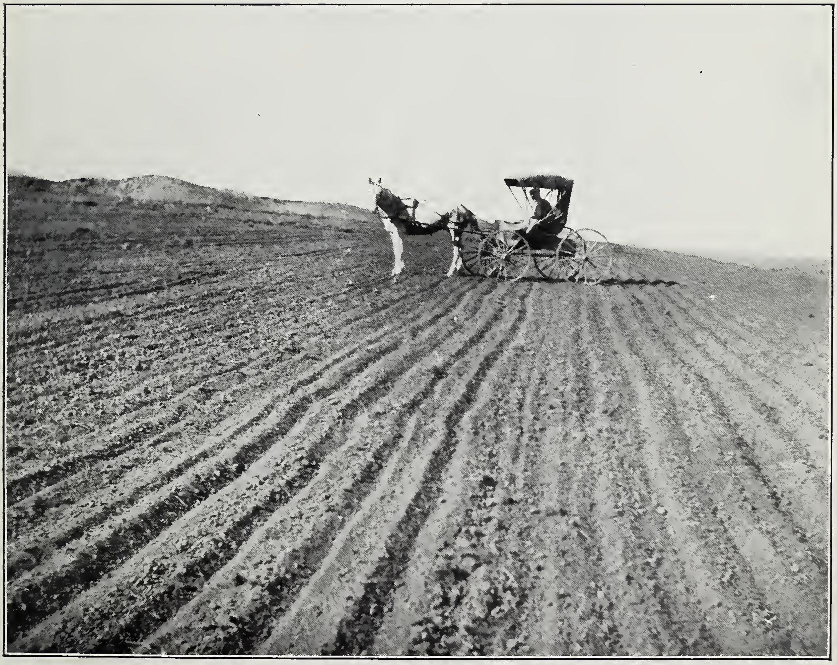

FIG. 2.—VIRGIN SOIL READY FOR PLANTING TO WINTER GRAIN ON GRACE BROTHERS' FARM NEAR NEPHI, UTAH.

THE EXPERIMENTS.

All the crop work at the substation can be divided into two classes—plat experiments and nursery experiments. It is the object of the plat work to make tests of different crops and varieties and of different methods under field conditions. In the nurseries tests are made of individual plants on short rows and small plats. The nursery work yields results of a detailed nature, furnishes opportunity for studying plants individually, and makes possible the propagation of very small quantities of seed obtained from foreign countries and from different parts of this country. In the nursery facts are discovered which would be obscured in the plats. In short, the nursery work is intensive, while the plat work is comparatively extensive. The facts discovered in the nursery are ordinarily corroborated by tests in the plats before they are placed before the farmer. A brief discussion of the principal plat experiments being conducted, together with the results obtained, is given below.

PLAT EXPERIMENTAL METHODS.

The majority of the plats at the substation are 36 feet wide and 121 feet long, containing one-tenth of an acre each. In all the plat work an attempt is made to keep the conditions as nearly as possible like those found in well-kept fields, so that the results will be applicable to large fields. In most of the tests the plats are plowed with an ordinary 4-horse double-disk plow, 15 or 20 plats being plowed at the same time. Only field implements (plows, harrows, disks, and drills) are employed, except occasionally, when a hoe is used to remove small patches of weeds. Ordinarily, however, the plats receive only field treatment. Except where otherwise stated, all plats are plowed as soon as possible after the crop is removed. After being plowed they lie untouched until the following spring. During the next summer they lie fallow, are kept free from weeds, and are well cultivated.

GRAIN VARIETY TESTS.

The variety tests include 60 varieties and strains of winter wheat, 1 winter oat, 2 winter barleys, 1 winter emmer, 10 spring wheats, 6 spring oats, and 3 spring barleys. There are 84 varieties of grain being tested under field conditions in plats. In these tests it is provided, so far as is possible, that all differences in yield and quality shall be due to variety characteristics. All varieties of winter wheat, for example, are treated in the same manner. The seed is all treated with formalin solution to prevent bunt (smut). The varieties are all planted during two or three days—usually about October 1 to 15—on soil that has lain fallow for one year. This soil all receives the same treatment both before and after the grain is planted. The wheat varieties are planted at a uniform rate of 3 pecks per acre, a 10 by 7 disk drill being used. The soil on the substation is fairly uniform, and check plats are planted—all to the same variety—in various parts of the field, to indicate any soil differences. This makes it possible to get results sufficiently reliable to warrant the selection of particular varieties as superior to others. During the growing season the grain varieties are usually harrowed at least once to break up the crust formed on the soil during the winter.

SUPERIORITY OF WINTER VARIETIES.

In the Mountain States, where the rainfall is lowest during the summer months, winter varieties almost invariably produce higher yields than those planted in the spring. At the substation the winter-wheat varieties have outyielded the spring wheats from 30 to 300 per cent.

Table III gives the average yields of the winter and spring varieties of wheat during the past six years.

TABLE III.—*Average yield to the acre of winter and spring varieties of wheat grown at Nephi, Utah, from 1904 to 1909, inclusive.*

Year.	Winter wheats.		Spring wheats.	
	Number of varieties.	Average yield to acre.	Number of varieties.	Average yield to acre.
		Bushels.		*Bushels.*
1904 [a]	9	20.31	4	18.45
1905 [a]	9	6.91	4	7.07
1906 [a]	9	26.62	4	9.85
1907	8	30.98	4	21.66
1908	60	25.60	11	12.48
1909	60	11.12	9	9.83
Six-year period		20.26		13.22

[a] Bulletin 100, Utah Agricultural Experiment Station.

Table III shows a difference of 7.04 bushels to the acre in favor of the winter wheats. These figures, together with the fact that these wheats have the advantages of longer straw, greater uniformity, and earlier time of ripening, leave absolutely no doubt that they are to be much preferred. Whether the same preference should be shown the winter oats and barleys is not so certain as yet. Experiments with these grains will be discussed later.

LEADING VARIETIES OF GRAIN.

WINTER WHEATS.

Of the 60 varieties tested, the Turkey wheat (G. I. No. 2998[a]) has been the highest yielder. At the time cooperative work was started, July, 1907, only 9 winter wheats were under test. Since then 51 varieties and strains have been added. The Turkey (G. I. No. 2998) was one of the varieties grown before 1907, it having been grown at the substation since 1904. Its yield, which has been the highest of the varieties tested, is given in Table IV in comparison with the yields of the Koffoid and the Gold Coin, the two most widely grown varieties in the Great Basin area.

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[a] Grain Investigations Number.

TABLE IV.—*Average yield to the acre of the Turkey, Koffoid, and Gold Coin varieties of wheat grown at Nephi, Utah, from 1904 to 1909.*

Years tested.	Turkey (G. I. No. 2998).	Koffoid.	Gold Coin.
	Bushels.	*Bushels.*	*Bushels.*
1904–1906 average[a]	24.96	18.25	15.09
1907–1909 average	30.40	28.18	25.53
Six-year average	27.70	23.23	20.39

[a] Bulletin 100, Utah Agricultural Experiment Station.

Table IV shows that the Turkey variety has averaged decidedly better than either the Koffoid or the Gold Coin during the past six years. The superiority of this variety has been most strikingly evident in comparatively unfavorable seasons. When there has been an abundance of rainfall during the growing season its yield has not so far exceeded that of the Koffoid or the Gold Coin. In 1907, when the seasonal rainfall was admirably distributed, June receiving 1.58 inches, it yielded 37.70 bushels per acre. The Koffoid in the same year produced 38.20 bushels per acre. During all the other years the Turkey has led all the varieties. The results with the variety test indicate strongly that for conditions similar to those at Nephi the Turkey wheat is the best of the 60 varieties on trial.

Description of Turkey wheat.—The Turkey is a hard red winter wheat, belonging to a class of wheats introduced into the United States from the Crimean district of Russia. It grows at Nephi to a height of about 30 to 35 inches; it has very little foliage, a slender, medium stiff straw, a yellowish-white chaff, and moderately long, soft awns or beards. The quality is of the best, and up-to-date millers now show it a strong preference. Farmers who have always grown beardless wheats frequently object to Turkey on account of its beards, but the importance of this objection is greatly exaggerated. The farmers of Kansas produce annually 70,000,000 bushels of wheat of this class and will grow no other. They do not regard the beards as a serious objection when the superior quality and yielding power of the variety are considered.

SPRING WHEATS.

Although, as already shown, it is not ordinarily advisable to grow spring wheats in the Mountain States, there are sometimes conditions which may prevent a farmer from getting his winter wheat planted and under which it is better for him to grow a spring wheat than to let his land lie idle for a year. When such an occasion arises it is important to know something of the comparative values of spring varieties.

Until 1908 only the durum (macaroni) spring varieties were tested on the substation. The average yield of the four tested (the Kahla, Adjini, Medeah, and Mohamed ben Bachir varieties) during the years 1904 to 1907 was 12.48 bushels per acre. In 1908 the Kahla and the Medeah were discarded and the Kubanka (G. I. No. 1440) was added. In the same year five varieties of common spring wheats were introduced.

COMMON AND DURUM WHEATS.

The durum wheats have been found superior to the common spring wheats in a great many arid sections on the Great Plains. The common varieties seem, however, to be better adapted to the conditions at Nephi. The average yield of the durum wheats during the past six years at Nephi is 10.06 bushels per acre. The average yield in 1908 and 1909 is 8.84 bushels, while the common varieties during the same two years averaged 13.03 bushels. The comparison of two years' results is not, of course, conclusive.

COMMON SPRING VARIETIES OF WHEAT.

The common spring varieties now under test are the Galgalos, the Ghirka Spring, the New Zealand Spring, and two unnamed varieties from Mexico. With the two years' results obtained it is not possible to determine which is best. The yields of these varieties during 1908 and 1909 are given in Table V.

TABLE V.—*Yield to the acre of five varieties of common spring wheat grown at Nephi, Utah, during 1908 and 1909.*

Variety.	Yield in 1908.	Yield in 1909.	Average yield.
	Bushels.	*Bushels.*	*Bushels.*
Ghirka Spring	13.33	6.70	10.01
Galgalos	12.00	12.15	12.07
Mexican, No. 1	22.66	10.94	16.80
Mexican, No. 2	12.66	14.66	13.66
New Zealand Spring	23.25	13.21	18.23

In 1908 the New Zealand Spring wheat was grown on soil that had been fallow two years, and hence had presumably some advantage. It is, however, a very good variety and shows considerable drought resistance. The test will have to be continued for a few years more before positive preference can be given, but the results with this variety indicate that it can be grown with a fair degree of success in cases where spring planting is necessary.

WINTER OATS.

The only variety of winter oats on trial at the substation is the Boswell Winter. This is a black oat, which came from England about ten years ago. It was propagated by Mr. Stephen Boswell, Nephi, Utah. The yields at the substation have not been as large as those obtained by Mr. Boswell on his farm, which adjoins the substation on the south. In 1907 the crop was planted on land that had produced a crop of wheat that year, and so much volunteer wheat grew that it was impossible to determine the oat yield in 1908. The 1908 yield on the Boswell farm was 50 bushels per acre. In 1909 the yield obtained at the substation was 16 bushels and on the Boswell farm about 40 bushels to the acre. A beating storm greatly reduced the yield on the experimental plat after the crop on the Boswell farm was harvested and in the stack.

A large quantity of seed of this oat has been planted in different parts of the Mountain States. The reports show varying degrees of success, but the majority indicate that the variety will become quite popular. The color of the hull is a commercial objection, but of course has no ill effect on the feeding value. This is comparatively high. As feed for farm animals particularly, the production of this winter oat is recommended.

To farmers who expect to try the Boswell Winter oat it should be stated that its habit of growth is likely to be misleading. It grows very slowly and in a "creeping" manner during the autumn and spring. Until the middle of June it shows no sign of erect growth and appears so lacking in vigor that in some cases farmers have decided that the crop was a failure and have plowed it under. About June 15, however, erect growth commences and the stalks spring up with remarkable rapidity. This variety tillers, or "stools," very heavily, so that when the heads appear, about the last of June, it is seen that a crop of surprising abundance has been produced from what looked like a failure a month earlier.

SPRING OATS.

Six varieties and strains of spring oats are being tested. Three of these—the Sixty-Day, the Black American, and the Giant Yellow—have been grown since 1904. The Swedish Select and an improved strain of the Sixty-Day were obtained from Highmore, S. Dak., in 1908, and have been grown for two years at the substation. The Kherson, a variety which is botanically identical with the Sixty-Day, was tried in 1909, the seed coming from Akron, Colo. The yields of these varieties are given in Table VI.

TABLE VI.—*Yield to the acre of six varieties or strains of spring oats grown at Nephi, Utah, from 1904 to 1909, inclusive.*

Years.	Black American.	Giant Yellow.	Sixty-Day (Nephi).	Sixty-Day (Highmore).	Swedish Select.	Kherson.
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
1904–1906 average[a]	31.70	24.66	22.62			
1907–1909 average	25.33	19.51	20.87			
Six-year average	28.51	22.08	21.74			
1908–9 average				31.27	28.82	
1909						19.19

[a] Bulletin 100, Utah Agricultural Experiment Station.

Table VI shows that the Black American stands first among the three varieties grown during the past six years and that the Giant Yellow is slightly superior to the Nephi strain of Sixty-Day. Although the Highmore strain of Sixty-Day and the Swedish Select have been tried only two years it is believed that they will prove better yielders than the Black American or the Giant Yellow. Whether this is true can be determined only by further testing.

The Swedish Select and the Sixty-Day have the advantage of the Black American in the matter of color, and they are far superior to the Giant Yellow in uniformity of ripening. This is very much in their favor. In the matter of earliness the Kherson and the Sixty-Day lead. They ripen 10 to 15 days earlier than the Swedish Select, 10 days earlier than the Black American, and 15 days earlier than the Giant Yellow. The Swedish Select grows from 26 to 36 inches tall, depending on the season; the other varieties all average about 6 inches shorter. Until additional data are secured it will not be possible to state positively whether the spring oat varieties will be better than the winter oat, but it is believed that when the latter becomes thoroughly winter-hardy it will excel those planted in the spring.

WINTER BARLEYS.

Only one year's results have been obtained with winter barleys. Utah Winter barley (G. I. No. 592) was tested in 1909. The seed of this variety was obtained from the Boswell farm, where it produced about 50 bushels per acre in 1908. In 1909 the yield at the substation was 25.9 bushels per acre, a very satisfactory yield for such a dry season. The other winter barley tested in 1909 at the substation is Tennessee Winter (G. I. No. 257). It yielded 18.1 bushels per acre. These two barleys grow from 25 to 30 inches tall, and ripen 10 days earlier than the spring barleys. Their quality is excellent. It is thought that further testing of these varieties will prove their right to recognition as dry-land crops, but until several years' results are obtained no positive statements regarding their yielding power can properly be made.

SPRING BARLEYS.

Two varieties of spring barley, the California and the California Prolific, have been grown at the substation for six years. One other, a hull-less, beardless variety, was tested in 1907, 1908, and 1909. The average yields of these are given in Table VII.

TABLE VII.— *Yield to the acre of three varieties of spring barley grown at Nephi, Utah, from 1904 to 1909, inclusive.*

Years.	California.	California Prolific.	Hull-less.
	Bushels.	*Bushels.*	*Bushels.*
1904–1906 average [a]	24.30	22.36	....
1907–1909 average	19.97	21.65	13.58
Six-year average	22.14	22.00	....

[a] Bulletin 100, Utah Agricultural Experiment Station.

As shown above, there is practically no difference between the yields of the California and California Prolific barleys. The two strains are botanically identical also. The Hull-less variety has been a very poor yielder. All three have very short straw. They grow about 6 inches shorter than the winter barleys, and are for this reason very difficult to harvest with either binder or header. It is believed that the winter varieties, especially the Utah Winter barley, will be found preferable as dry-land crops for the Great Basin area.

WINTER EMMER.

Emmer is one of the least-known grains in the United States. Botanically it is closely related to wheat, but its position in farm economy is more nearly like that of barley, since it is valuable principally as a stock food. It resembles barley also in that the glumes (chaff) adhere to the kernel when the grain is thrashed. There are both winter and spring varieties, but only a winter variety, Black Winter emmer, has been tested on the substation plats. Its ability to resist drought has been satisfactorily demonstrated and at Nephi it has proved extremely hardy.

In 1908 it yielded 41.33 bushels per acre; in 1909 the yield was 43.66 bushels, the 2-year average being 42.49 bushels per acre. The grain weighs about 30 pounds per measured bushel. Although its feeding value is not definitely known, it is thought to be about equal to that of barley and is much relished by horses, hogs, and sheep. The hardiness and drought resistance of Black Winter emmer and its high yield and excellent feeding qualities make it a particularly desirable grain for dry-land farmers who wish to raise their own stock feed.

Emmer should be treated about the same as winter barley. It is best planted with a press drill at the rate of 5 pecks per acre at the time winter wheat is planted (see "Time of planting winter wheat" in this circular). It ripens about July 20, and can be harvested with either a binder or a header.

SUMMARY.

From the preceding discussion of the results obtained to date at the Nephi substation in the work with grain varieties it is desirable that the following points be kept in mind:

(1) That winter grains, particularly the winter wheats, are to be preferred to spring grains.

(2) That the Turkey winter wheat during the past six years has yielded more than any other variety tested; that its 6-year average exceeds that of the Koffoid variety by 4.47 bushels per acre and that of Gold Coin by 7.31 bushels per acre; that the quality of the Turkey wheat is considerably better than the quality of the Koffoid or the Gold Coin, and that in unfavorable seasons and under the driest conditions the superiority of the former is most evident.

(3) That the common varieties of spring wheat have outyielded the durum varieties during the past two years, the former averaging 13.3 bushels per acre as against 8.84 by the latter, and the 6-year average of the durum wheats being only 10.06 bushels per acre.

(4) That in the past two years the New Zealand Spring wheat has shown considerable promise as a spring grain, but that further testing is necessary to a definite determination of the best variety.

(5) That the Boswell Winter oat promises to become a very valuable crop on the dry lands and that it has already met with considerable success in different sections of the Mountain States.

(6) That the Black American leads in the 6-year average of three spring oats, but that the Sixty-Day and the Swedish Select varieties promise to prove better yielders upon further testing, while they have the advantage of white color.

(7) That the 1-year test of winter barleys indicates that they will be preferable to spring barleys in height, yield, and quality.

(8) That Black Winter emmer, a new grain on the dry lands, has averaged 42.49 bushels per acre during the past two years and that its winter hardiness, drought-resistance, high yield, and excellent feeding quality make it a most desirable crop to grow for stock feed for the dry lands.

FARMING METHODS IN GRAIN PRODUCTION

For the purpose of determining the most satisfactory methods to be followed in the production of grains, particularly wheat, on the dry lands, a number of experiments are being conducted at the substation. In each of these tests a single variety is used, so that differences in yield may indicate the values of the different methods.

PLOWING.

SPRING COMPARED WITH FALL PLOWING.

A wide diversity of opinion exists among the farmers of the Mountain States as to the relative value of spring plowing and fall plowing. A test of the two methods is conducted at the substation. One plat is plowed as soon as possible after the wheat crop is removed in the autumn and is allowed to lie untouched until the following spring. The other plat is plowed in early May. After this plat is plowed, the two plats are treated in exactly the same way, both lying fallow during the summer and being planted to one variety of wheat the following autumn. The test seeks to determine (1) the effects of the fall and spring plowing on the moisture conditions, (2) the influence on the crops produced by the two plats the following year, and (3) the comparative expensiveness of the two methods. The test was not begun at Nephi until the fall of 1908, and only the moisture studies for one year, 1909, are available, in addition to the observations made on relative expensiveness.

The principal argument advanced in favor of fall plowing is the belief that more moisture is thereby conserved. Widtsoe and Merrill [a] note an instance in which they found a difference amounting to ''more than 506 tons of water to the acre in the first 5 feet of soil'' in favor of land plowed in the fall. The results of the 1909 work at Nephi, however, showed no advantage of either method in the matter of water conservation. The two plats were sampled on April 5, June 26, and September 18 to a depth of 6 feet, and no important differences in moisture content were found. Whether the 1909 soil-moisture conditions on those two plats were normal or exceptional can be determined only by future studies. It is believed that in years having comparatively dry winters the fall plowing would prove a benefit.

The first crop to be grown in this test was planted in the autumn of 1909. It is believed that this crop will show some difference in favor of one or the other method, if there is a difference in the desirability of either. There is a possibility that, aside from considerations of moisture, fall-plowed soil will prove more productive than soil plowed in the spring. When the land is plowed in the fall and left in a rough, lumpy condition through the winter, the soil is probably much more benefited by weathering agencies than stubble soil can be. This may react favorably on the crop.

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[a] See Bulletin 91, Utah Agricultural Experiment Station.

The factor of expense in fall and spring plowing is very important, and unless a considerable difference in yield is attributable to one method or the other it will be the principal determining factor in deciding which method is best to follow. Plowing in the fall is ordinarily more difficult than spring plowing, because the soil is usually dry and hard after the crop is removed. There are advantages in doing the work in the autumn, however, because at that time the farmer is not as a rule so rushed with work as in the spring, and because the price of horse feed is lower in the fall. All things considered, it is probable that the expense of the actual plowing is about the same for both methods. Fall-plowed land is more likely to be infested with weeds during the fallow period than spring-plowed land. At the substation in 1909 the fall-plowed plat required more than twice as much weeding as the plat plowed in the spring. In fact, the latter was almost entirely free from weeds and volunteer wheat from the time it was plowed, May 15, until planting time. This point, considered by itself, is decidedly in favor of spring plowing. The factor of weediness is successfully met by the Grace Brothers, at Nephi, Utah. They plow their land in the fall in the ordinary way, allow it to lie uncultivated until early June, when the weeds and volunteer wheat are well started, and then give it a very shallow plowing. They usually have little difficulty with weeds after the second plowing, and their grain yields are exceptionally good. The expense is no greater than it would be to eradicate the weeds by disking and harrowing. Whether this method will be successful on other farms is not known, but its success on the Grace farm strongly suggests the advisability of its trial by farmers who have difficulty in keeping their fall-plowed fallow land clean.

There are yet several problems to be scientifically worked out before the superiority of fall plowing or spring plowing can be positively known. The future behavior of the crops in this test at the substation will doubtless throw considerable light on the question. If it is found that one method produces as high a yield as the other, then the question will have to be settled by each farmer for himself, according to his own conditions and convenience. The most successful dry farmers in the Mountain States practice fall plowing; the general practice of the substation is to plow in the fall, and the results are satisfactory; so that it is believed in the light of the present knowledge that fall plowing is to be generally preferred.

DEPTH OF PLOWING AND SUBSOILING.

The substation in 1908 started a test to determine the best depth to plow wheat land and the value of subsoiling. In the fall of 1908 four plats which had produced a crop of wheat that year were treated as follows:

Plat 16 A, plowed 7 to 10 inches deep with an ordinary plow and subsoiled to a depth of 18 inches.

Plat 17 A, plowed 7 to 10 inches deep with an ordinary plow and subsoiled to a depth of 15 inches.

Plat 18 A, plowed 10 inches deep in the ordinary way.

Plat 19 A, plowed 5 inches deep in the ordinary way.

After receiving this treatment these plats were left untouched until April, 1909. From this time they were treated as ordinary fallow plats and were planted to winter wheat in the fall.

The moisture content of each plat was determined at three periods during the season, viz, April 6, July 28, and September 23. No very great differences were noted in the moisture of the four plats, although the two subsoil plats contained slightly more water on July 28 than did the plats that were plowed to depths of 5 inches and 10 inches, respectively. It will require several years to determine with certainty the relative values of the various treatments. In 1910, while the plats named above are producing a crop of wheat four other plats which were plowed and subsoiled in the fall of 1909 will lie fallow and will receive the same treatment that plats 16 A, 17 A, 18 A, and 19 A received in 1909. By growing wheat crops on the variously treated plats and by making moisture determinations from time to time it will be possible to study the effects of the treatments very satisfactorily.

The most successful practice at present on the dry lands is to plow to a depth of from 7 to 10 inches. There have been instances where plowing deeper than 10 inches and even subsoiling to a depth of 15 to 18 inches have given profitable returns, but until the actual results of these methods are scientifically determined, as contemplated by the test at the substation, plowing 7 to 10 inches deep is recommended.

CARE OF FALLOW SOIL.

OBJECTS.

The principal objects sought in the care of fallow land are (1) the conservation of soil moisture accumulated during the year for the use of the next crop, (2) the eradication of weeds and volunteer grain which, if allowed to grow and produce seed, would be damaging to the wheat crop, and (3) the securing of a satisfactory seed bed.

MOISTURE CONSERVATION.

As previously stated in the discussion of time of plowing, the land to be fallow at the substation is plowed as soon as possible after the crop is removed and is allowed to lie in a rough condition until the following spring. The storms of winter and the wide variations of temperature occurring between autumn and spring break up the large chunks of hard, dry soil that are turned up in the fall plowing, leaving the surface soil fairly smooth and usually somewhat crusted. If this crust is allowed to stand, the loss of soil moisture through evaporation will be enormous. For this reason the land should be shallow cultivated as soon as the surface soil is sufficiently dry to be worked without danger of puddling. Great care should be taken to avoid packing the soil by working it when it is wet. This caution is particularly necessary in the care of clay soils. The first spring cultivation can be made with an ordinary spike-tooth harrow, or, if the crust is too hard to be broken up by this means, with a disk harrow. If the latter is used, the land should be double disked to prevent ridging, and the disk harrow should be followed by the spike-tooth harrow. After the first spring cultivation, the soil will need no more working until rains have formed another crust or until the weeds and volunteer grain begin to grow, when the shallow cultivation should be repeated.

In order to show the effect of cultivation of fallow soil on the moisture content, a test was started at the substation in 1909. One plat, 14 A, was cultivated during the summer in the usual way, the surface soil being kept loose throughout the season, and one plat, 15 A, received no cultivation from the time it was plowed in the autumn of 1908 until just before it was planted in October, 1909. The moisture contents of the two plats were determined on May 21, July 15, and September 18. The first determination, May 21, showed that the two plats contained substantially equal quantities of water, but subsequent measurements showed that the uncultivated plat lost its moisture to a very much greater extent than did the cultivated plat. The total amount of water lost by the cultivated plat during the season was less than 7 per cent of its moisture content as determined May 21, while the loss from the uncultivated plat amounted to 23 per cent, or more than three times the loss from the cultivated plat. These moisture contents were determined to a depth of 6 feet, and the figures above represent the average content of the 6 feet on each plat. When the upper 2 feet are considered, still greater differences in favor of cultivation are observed. The cultivated plat lost during the season but 10 per cent of the water in the first 2 feet. The uncultivated plat lost 37 per cent. When it is remembered that the young wheat

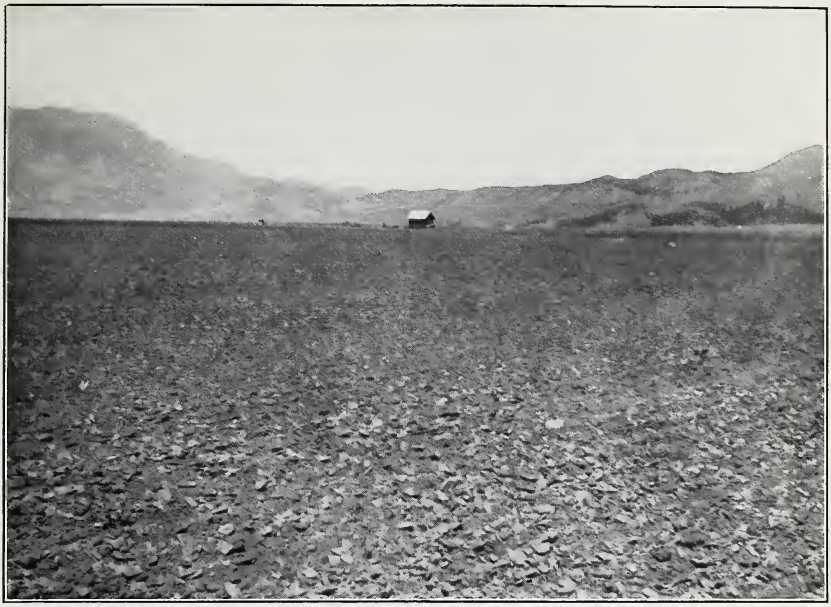

FIG. 1.—FALLOW SOIL AT THE NEPHI SUBSTATION, SHOWING THE DESIRED CONDITION OF THE SURFACE SOIL AFTER THE CRUST IS BROKEN.

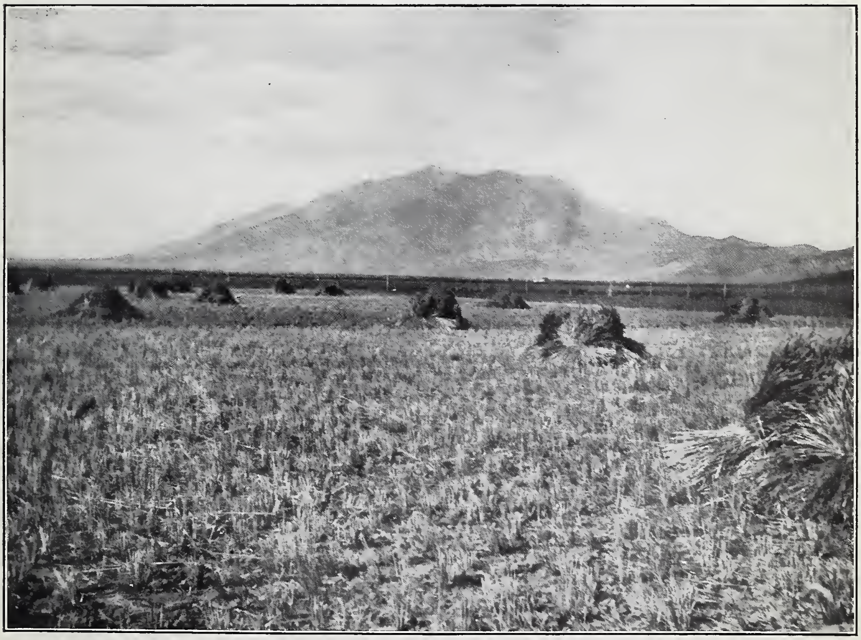

FIG. 2.—VIEW OF PLATS OF KOFFOID WINTER WHEAT IN THE TIME-OF-PLANTING TEST AT THE NEPHI SUBSTATION, 1909.

plants must obtain their water supply from the surface soil the importance of conserving that water during the fallow season is obvious and the value of cultivation, as illustrated by the data given above, is strikingly noticeable.

It is often stated that it is impossible to cultivate fallow soil too much. This is not always true, especially on heavy clay soil. If such a soil is harrowed until the surface is a very fine dust, it crusts very readily after a rain, and packs extremely hard. It is well to keep the surface soil loose and light, but the maintenance of a "dust mulch," strictly speaking, is not desirable. (See Pl. I, fig. 2, and Pl. II, fig. 1.) On light, sandy soils the danger of excessive cultivation, however, is not so important.

WEED ERADICATION.

The operations necessary to prevent the growth of weeds on fallow soil are closely related to those employed to conserve soil moisture. A cultivation that will destroy weeds will also break up a soil crust, and cultivation made to pulverize the surface soil will frequently destroy large numbers of small weeds. Ordinarily, if the amount of tillage necessary to maintain a good soil mulch is carried on, the weeds will be destroyed incidentally. There are cases, however, when cultivation is necessary entirely on account of weeds. In such cases the all-important requisite is to do the work at the proper time. If the soil is carefully watched it will be noticed that at times during the summer the ground is literally covered with weeds, so small as to escape casual observation. If the land is treated to a light harrowing at exactly the time when these weeds are beginning to appear in great numbers, highly satisfactory results may be obtained. This has been repeatedly demonstrated at the substation. A very few days' delay, however, will make it necessary to use a disk harrow. This operation costs more than a light harrowing and is less desirable because it exposes more moist soil to the drying effects of sun and wind. The more shallow the fallow cultivation is, so long as it keeps down the weeds, the better.

Where an unusual number of weeds are present on fallow soil, as is sometimes the case when the land has been plowed in the fall and where it is impossible to cultivate at the critical time, the method of plowing in early June, as practiced by the Grace Brothers, is highly satisfactory. When this method is followed the land is left until practically all the weeds likely to grow are up. The plowing is then done, as shallow as possible, to avoid exposing unnecessarily the moist soil near the surface, and the plows are followed immediately by the spike-tooth harrow. The harrowing reestablishes the desired soil mulch and exposes the roots of the weeds to the destructive action of the sun and wind.

There will usually be no great difference in the cost of the two methods of weed eradication. The second-plowing method is slower, but it ordinarily avoids the necessity of such frequent harrowing or of disking and harrowing. In considering the advisability of using one method or the other, the farmer must study his own conditions and determine which method is most likely to meet them. In the whole matter of weed eradication on fallow soil it is important that the necessity of doing the work at the right time, of preventing the weeds and volunteer grain from producing seed, and of avoiding very deep cultivation be kept in mind.

SEED-BED PREPARATION.

If the best methods of soil moisture conservation and of keeping down weeds and volunteer grain are followed during the spring and summer months, the seed bed will usually be found to be in excellent condition at planting time. The seed bed should be firm and uniform, with the soil under the mulch sufficiently moist to furnish the young plants the necessary water. In light and sandy soils the mulch at planting time is frequently found to be very light and to lack the necessary firmness. This condition can be readily remedied by the use of a wooden leveler or smoother just before the grain is planted. Clay soils almost invariably settle sufficiently, of their own weight, to make the use of the smoother unnecessary. The importance of a good seed bed can scarcely be exaggerated. If the grain is planted in soil that is ragged and lacking in uniformity, a poor and irregular stand is sure to be the result, and all the work that can subsequently be done on the land can not correct this condition. On the other hand, if the seed bed is properly prepared the wheat crop will survive severe conditions to an extent that is impossible on a poorly prepared seed bed. The proper preparation of the soil before planting time is very frequently the determining factor in obtaining a profitable crop.

SEED AND SEED TREATMENT.

PURE SEED.

The profits of dry-land grain production are much increased by using only pure seed, and a great many failures are due to the use of inferior varieties or impure seed. If the seed planted is of more than one variety, losses are likely to follow on account of irregularity in the time of ripening, which results in the shattering of large quantities of the early-maturing grain. Furthermore, mixed grain is never as likely to command top prices as grain of one variety. The inadvisability of planting grain containing weed seeds is too well known to require extensive discussion. In selecting seed grain the farmer should obtain the best-known variety grown in his locality or in a locality of similar conditions. He should see that the seed is as nearly as possible of one variety and that all weed seeds and light or shrunken kernels of grain are removed from the seed before planting. The cleaning is quickly and easily done by the use of a common fanning mill, which can be purchased for about $40. This simple machine should be included in the equipment of every grain farm.

TREATMENT FOR BUNT.

The Mountain States are very fortunate in having few grain diseases. Bunt (stinking smut) is the only disease that commonly causes serious damage to the dry-land wheat crop. This disease can usually be avoided by soaking the seed from 5 to 10 minutes in a solution of formalin, consisting of 1 pound of 40 per cent formaldehyde in 40 gallons of water. If possible, the farmer should use seed that contains little or no smut. If there are smut balls present in the seed, they should be removed by pouring the grain into a tank of water and skimming off the smut balls as they rise to the surface. If this is done, the seed carefully treated, and the drills thoroughly washed out with the formalin solution, there is very little danger that the resultant crop will be smutted.

PLANTING AND CARING FOR THE CROP.

TIME OF PLANTING WINTER WHEAT.

One of the most important factors in the growing of winter wheat is the time of planting. The variations in the character of the seasons play an important part in this test. The results have not been the same every year, but by considering the average yields produced by planting on different dates and by studying the behavior of the crops under varying seasonal climatic conditions it is possible to arrive at some valuable and definite conclusions.

In this experiment one plat is planted on fallow soil at the rate of 3 pecks per acre on each of the following dates: August 15, September 1, September 15, October 1, October 15, and November 1. (See Pl. II, fig. 2.) In 1904–1907[a] the Odessa variety was used. In 1908 and 1909 the Koffoid was used in place of the Odessa, on account of its being much more widely grown in the Mountain States, particularly in the Nephi district. From 1910 both the Koffoid and the Turkey varieties will be used.

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[a] The results in 1904–1906 are reported by Mr. W. M. Jardine in Bulletin 100 of the Utah Agricultural Experiment Station. In 1907–8 the test was conducted by the Utah station independently and the results have not before been published. Their use here is made possible through the courtesy of Dr. E. D. Ball, director, and Prof. L. A. Merrill, agronomist in charge of arid farms, Utah Agricultural Experiment Station. Since the autumn of 1908 the work has been done cooperatively.

The yields, in bushels of grain per acre, for six years, are given in Table VIII.

TABLE VIII.—*Yield to the acre of winter wheat planted at Nephi, Utah, at 15-day intervals from August 15 to November 1 of each year from 1904 to 1909, inclusive.*

Date planted.	1904.	1905.	1906.	1907.	1908.	1909.	Six-year average.
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
August 15	11.80	9.41	20.50	[a] 33.50	3.16	[a] 29.33	17.95
September 1	8.25	10.66	31.20	[a] 33.91	6.41	[a] 31.50	20.32
September 15	9.66	2.33	22.80	29.16	11.33	20.66	15.99
October 1	19.66	11.50	31.20	25.00	12.25	32.42	22.00
October 15	22.78	17.30	27.50	30.08	21.66	17.25	22.68
November 1	21.33	18.66	28.70	29.16	23.33	1.58	20.46

[a] Grain badly shrunken.

Factors in early planting.—There are several important points to consider in connection with time of planting. The behavior of the crop is determined largely by the amount of moisture in the soil, particularly in the surface foot, at the time the planting is done and by the temperature. When the grain is planted early—August 15 to September 15—there are two possible dangers. The first is that the moisture may be sufficient to start the growth of the plants but insufficient to maintain the growth during the long dry periods which commonly occur during September and October. In this case a large number of the plants die from lack of moisture and a thin and irregular stand results. The other danger of early planting is that the plants during their long growing period in the autumn develop too extensive root systems. The result of this is that the crop produces such extensive foliage during the early part of the following summer that by the time the dry weather of June and early July comes the soil moisture is exhausted. The moisture that should have been saved for use in the fruiting period is consumed in the production of foliage. The result is a great deal of straw and a relatively small quantity of grain, usually shrunken. This was well illustrated by the results in 1909, as shown in Table IX.

TABLE IX.—*Yield to the acre of grain and straw and proportion of grain to straw of winter wheat planted at Nephi, Utah, at 15-day intervals from August 15 to November 1, 1908.*

Date planted.	Yield per acre.		Proportion of grain to straw.	
	Grain.	Straw.	Grain.	Straw.
	Bushels.	*Pounds.*	*Pound.*	*Pounds.*
August 15	29.33	3,450	1	1.96
September 1	31.50	2,690	1	1.41
September 15	20.66	1,420	1	1.15
October 1	32.42	2,165	1	1.11
October 15	17.25	965	1	.93
November 1	1.58	100	1	1.05

While Table IX does not show a uniform relation between the yield and the ratio of grain to straw, it indicates the relatively large quantity of straw produced by the early planted plats. The highest grain-yielding plat, planted October 1, produced about the normal amount of straw, the ratio being 1 to 1.11. The grain produced on this plat was plump and sound, while that on the plats planted August 15 and September 1 was badly shrunken. The dangers incident to heavy foliage production are not so great when the summer is comparatively wet. In fact, if there is plenty of moisture all through the growing season, heavy foliage is not a disadvantage at all, but the Mountain States very seldom experience wet summers. The disadvantages of early planting, then, lie in the danger of autumn drought and, in the absence of this, in excessive foliage production.

Factors in late planting.—When wheat is planted late—November 1 or thereabout—there is a strong likelihood that it will not come up until the following spring. Frequently this is not a disadvantage, but it is usually found best to have the plants up in the autumn, especially if the soil contains seed of weeds that germinate early in the spring. Where this is the case, the wheat plants are in danger of being crowded out in the struggle for growing space that invariably takes place when plants of different kinds occur on the same soil. If the wheat gets a good start in the autumn there is little danger that the weeds will crowd it out. Late planted wheat has another disadvantage—the danger of injury from low temperatures at the time the seed is germinating. In early November the temperature is often high enough for a few days to start germination, but it very frequently falls to zero so suddenly that the young and sensitive plantlets are killed or seriously injured. This sudden cold results in a poor stand of plants with impaired vigor. The likelihood of the crop failing to germinate in the autumn and being crowded out by weeds and the dangers incident to unfavorable temperatures, then, are the principal reasons why late planting should be avoided.

The best time to plant.—No particular time can be positively designated as the best time to plant. There are cases where very early planting has produced better results than medium or late planting; occasionally late planting produces maximum yields. The main factors to be considered in connection with early planting and with late planting have been already described. There are seasons when these factors do not operate undesirably. There are doubtless localities where early planting is invariably to be preferred, and there are others where late planting always gives the best results. In the Mountain States, where the rainfall is never very high, a variation of an inch or two one way or the other may produce striking effects, and such variations frequently occur. The records covering a number of years show, however, that on the average the summers are very dry and that there are usually long dry periods in September and October. With these facts in mind it is plain that the grain should be planted at such a time as to insure the crop against the possible ill effects of the dry spells which can reasonably be expected. The undesirable influences of low and varying temperatures common in the month of November should also be guarded against. The results at Nephi, as previously reported in these pages, for the six years 1904 to 1909, indicate that the middle course—planting from about September 20 to October 20—is the most favorable. There will undoubtedly be occasional cases in favor of the early or of the late planting, but for a practice to be followed through a series of years the medium dates will likely prove the most dependable.

TIME OF PLANTING SPRING WHEAT.

Prior to the inauguration of the cooperative work at Nephi the Utah station attempted to conduct a test with spring wheat to determine the best time of planting.[a] It was found, however, that the weather conditions were so unreliable during the spring season that it was impossible to do the planting on the dates specified in the plan, and the experiment was abandoned. It is usually found satisfactory to plant spring wheat just as soon as possible after the snow is off the ground. Planting when the surface soil is wet, however, should be carefully avoided, particularly on heavy clay soils.

TIME OF PLANTING SPRING OATS AND BARLEY.

The same difficulties as are encountered in testing the best time for planting spring wheat operate in connection with oats and barley. These grains can be successfully planted at the same time as wheat.

RATE OF SEEDING WINTER WHEAT.

The test to determine the best rate of seeding has not progressed far enough to warrant the use of the results. All the varieties grown at the substation in the variety tests are seeded at the rate of approximately 3 pecks per acre. This rate has produced satisfactory results not only at the substation but also on the farms all over the mountain area. In deciding on the rate at which to seed, the farmer should consider two points, (1) the moisture demands of the crop during the dry season and (2) the danger of weeds. If the stand is too thick, the moisture in the soil will be exhausted before the crop is mature; if it is too thin, weeds are likely to come up and crowd out the wheat plants. The seeding rate that will best meet both these conditions depends on the condition of the soil and the quality of the seed. If the seed bed is properly prepared and the seed is well cleaned and pure, from 35 pounds to 45 pounds per acre is sufficient. Whether to sow 35 pounds or 45 pounds should be determined by the average size of the kernels to be planted, seed consisting of large kernels requiring the higher rate.

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[a] See Circular 3, Utah Agricultural Experiment Station.

RATE OF SEEDING SPRING GRAINS.

While no definite test is conducted at the substation to determine the best rate to seed spring wheat and spring barley, the variety test plats of these grains are planted at the rate of 3 pecks per acre for wheat and 5 pecks per acre for barley. These rates appear to be quite satisfactory. A test was conducted in 1909 with Sixty-Day and Swedish Select oats in which each variety was planted at the rate of 4, 5, and 6 pecks to the acre. The differences in yields were not large, but the thinner seeding, 4 pecks per acre, gave somewhat better yields and indicated that 5 pecks and 6 pecks are rather high rates, especially in a very dry season like 1909.

DEPTH OF PLANTING.

The results in testing the best depth of planting have been rather variable. Plats are planted at the depth of 1½ inches, 3 inches, and 6 inches, respectively. Until the test is continued considerably longer positive conclusions are unwarranted, but the indications favor 3 inches as the most desirable depth of the three. In 1909 the plat planted 1½ inches deep produced somewhat better than the one planted 6 inches deep. It is believed that 3 inches is sufficiently deep, if the seed bed is well prepared and a good drill is used.

BROADCASTING COMPARED WITH DRILLING.

It would naturally be thought that a test of the two methods of planting wheat, broadcasting and drilling, would be unnecessary. There are still a few advocates of the old method of planting by hand, however, and this test is conducted mainly as a demonstration of the inferiority of that method. The plat planted with the drill has invariably so far outyielded the other as to put the inadvisability of broadcasting beyond all question. The broadcasted plat has averaged from 2 bushels to less than 9 bushels to the acre, while the drilled plat has yielded between 20 bushels and 25 bushels per acre. There is no good reason why any dry-land farmer should not use a drill. No matter how small the field is, broadcasting should never be practiced.

AUTUMN CULTURE OF WINTER WHEAT.

Ordinarily, when the wheat is planted, no more work on the soil is necessary before spring. When, as sometimes occurs, the surface soil becomes heavily crusted as a result of beating rains, it may be advisable to harrow in the fall. If the plants are through the crusted soil there is less necessity for harrowing than when they are imprisoned beneath the crust. Early-planted wheat is especially liable to damage from crusting, as beating rains are more likely to occur in the early part of the autumn than they are in October and November.

SPRING CULTURE OF WINTER WHEAT.

While autumn culture of winter wheat is seldom necessary, spring culture is very frequently found advisable. This is especially true on heavy clay soil like that at the substation. The rain and snow of the winter season puddle the surface soil to a considerable extent and when it dries it becomes extremely hard. Harrowing greatly improves this condition. It breaks up the crust so as to allow the plants greater freedom for growth and at the same time pulverizes the surface soil in such a way as to prevent the loss of large quantities of soil moisture by evaporation. It also kills large numbers of weeds and thus greatly aids the wheat crop. In 1909 the substation started a test of the efficiency of spring culture of wheat. The yields of both the harrowed and unharrowed plats were so low because of poor stands due to winterkilling that they did not show the effect of the harrowing, but the moisture was much better conserved in the cultivated plat. Plat 19 D was harrowed the last of April and cultivated in early June with a special weeder (a light spring-tooth implement which affects the soil in a way somewhat similar to the effect produced by a sulky rake with the teeth pressed into the surface soil).

Plat 20 D was not cultivated at all. The moisture contents of the two plats to a depth of 6 feet, determined June 26 and August 12, are given below:

	June 26.	August 12.
	Per cent.	*Per cent.*
Plat 19 D (harrowed, etc.)	17.04	15.31
Plat 20 D (not cultivated)	15.97	11.73

This shows that the cultivated plat contained more moisture both at the time the wheat was heading, June 26, and at the time of maturity, August 12. Until the results of several years' tests are available it will not be possible to state definitely to what extent spring harrowing benefits the wheat crop, but the data obtained in 1909 relative to the effect on the moisture content indicates that, at least on clay soils, it may be of considerable advantage. On a light or sandy soil it is less likely to produce profitable returns.

Whether harrowing is necessary and the time at which it should be done must be determined by each farmer for his own conditions. If the soil is hard and baked on the surface or if the wheat plants are unable to get through the crust, harrowing is advisable. Sometimes the crust is of such extreme depth that there is danger of killing the wheat plants in tearing the crust to pieces. This is true, however, only in extreme cases and in such cases the crust has been successfully broken without injury to the plants by the use of a corrugated roller. If this method is followed and the roller leaves the surface soil packed, the land should be immediately harrowed. In most cases the work can be very successfully done with a common spike-tooth harrow. In breaking a crust of ordinary thickness and solidity there is absolutely no danger of seriously injuring the plants. Wheat plants can stand an amount of harrowing that is surprising to persons who have never harrowed the crop. The spring cultivation may be done any time before the wheat is "in boot." The sooner it is done after the surface soil is thoroughly dry the better, but the farmer need have no fear of injuring his wheat plants at any time before June 1.

FREQUENCY OF CROPPING AND CROP DIVERSITY.

Continuous cropping and fallowing.—The common practice on the dry lands of the Great Basin area is to fallow the wheat fields every other year. The primary object of this method is the conservation of two years' precipitation for the use of each wheat crop. In order to determine whether alternate fallowing is more profitable than fallowing one year in three, or two years in three, or whether it is profitable to fallow at all, a "continuous cropping and fallowing test" is carried on at the substation. The test includes nine plats; one produces a crop of wheat each year; two produce wheat alternately; three are devoted to the test of growing wheat two years followed by one year's fallow, one plat of the three being fallow each year; of the remaining three plats one is cropped to wheat each year, the other two lying fallow each year, thus testing the effect of cropping one year in three. The outline given below shows the method followed:

Plat No.	Test.	1909.	1910.	1911.	1912.	1913.	1914.
82	Continuous cropping	Wheat	Wheat	Wheat	Wheat	Wheat	Wheat.
83	Alternate cropping	Fallow	do	Fallow	do	Fallow	Do.
14 D	do	Wheat	Fallow	Wheat	Fallow	Wheat	Fallow.
84	Two years in three	do	do	do	Wheat	Fallow	Wheat.
13 D	do	do	Wheat	Fallow	do	Wheat	Fallow.
13 F	do	Fallow	do	Wheat	Fallow	do	Wheat.
85	One year in three	do	do	Fallow	do	do	Fallow.
12 D	do	Wheat	Fallow	do	Wheat	Fallow	Do.
12 F	do	Fallow	do	Wheat	Fallow	do	Wheat.

The nature of this test is such that a long series of years will be required in which to determine the merits of the various methods. Moisture determinations are made from time to time each season on these plats and will add valuable information in connection with the experiment. The indications to date are against continuous cropping.

Wheat following intertilled crops.—There is a possibility that the necessity of alternate fallowing may be reduced or avoided by the substitution of intertilled crops. The outline of an experiment which is conducted at the substation for the purpose of studying the question is given here.

Plat number.	1908.	1909.	1910.	1911.	1912.	1913.	1914.
12 B	Wheat	Fallow	Wheat	Fallow	Wheat	Fallow	Wheat.
13 B	do	Corn	do	Peas	do	Potatoes	Do.
14 B	do	Potatoes	do	Corn	do	Peas	Do.
15 B	do	Peas	do	Potatoes	do	Corn	Do.
12 C	Fallow	Wheat	Fallow	Wheat	Fallow	Wheat	Fallow.
13 C	Potatoes	do	Corn	do	Peas	do	Potatoes.
14 C	Peas	do	Potatoes	do	Corn	do	Peas.
15 C	Corn	do	Peas	do	Potatoes	do	Corn.

As shown above, the intertilled crops used in the test are corn, potatoes, and peas. A plat of fallow is carried in connection with the intertilled crops to serve as a check. Hence, each year there is a plat of wheat following fallow, one following corn, one after potatoes, and one after peas. The peas, potatoes, and corn are planted in rows and cultivated during the summer to prevent unnecessary water loss through evaporation. The moisture content of the soil on the plats is determined from time to time during the summer to show the effects of the various crops. As the test was only recently started, it is not known whether the system of growing intertilled crops in place of fallow will be practicable. The behavior of the soil moisture during 1908 and 1909 was such as to suggest the probability that corn and potatoes can be successfully substituted for the fallow if a variety of corn adapted to the conditions can be found. The results with potatoes have been particularly promising. This crop will be discussed later.

SUMMARY.

In connection with farming methods in grain production, as investigated at the substation and observed on farms in various parts of the Mountain States, the above discussion seeks to emphasize the following points:

(1) That fall plowing is generally to be preferred to spring plowing.

(2) That while subsoiling has shown some indications of being beneficial it is not yet known whether the practice will be profitable and that plowing to a depth of 7 to 10 inches will probably give satisfactory results.

(3) That the three principal objects sought in the care of fallow land—moisture conservation, prevention or eradication of weeds, and preparation of seed bed—are best secured by shallow cultivation of sufficient frequency to maintain the surface of the soil in a fairly loose and well-pulverized state, and that the importance of cultivating at the proper time is paramount.

(4) That only clean and pure seed of the best variety for the locality should be planted.

(5) That all wheat seed should be treated with a formalin solution to prevent bunt, and that smut balls should be removed from the seed before treatment.

(6) That both very early and very late planting should be avoided, experience at the substation strongly favoring September 20 to October 20 as the best time to plant winter wheat.

(7) That spring grains should be planted as soon as possible after the surface soil has become dry enough to be worked without danger of excessive packing or puddling.

(8) That the most satisfactory rates for seeding so far determined are as follows: Wheat, 35 to 45 pounds per acre; winter barley and spring barley, 5 pecks per acre; winter oats, 6 pecks per acre; spring oats, 4 to 5 pecks per acre, the lower rate being favored for the drier localities.

(9) That the most desirable depth for planting wheat on a well-prepared seed bed is about 3 inches.

(10) That broadcasting should never be practiced in grain production; all grain should be drilled.

(11) That it is sometimes advisable to harrow fall-planted grain in the fall to break up the surface crust and that this is not often necessary except with early planted grain; that spring harrowing is frequently advisable, particularly on heavy clay soils, and that there is ordinarily no danger of injuring the plants by harrowing at any time before June 1.

(12) That the indications so far are against growing wheat continuously and in favor of at least alternate fallowing, where wheat is the only crop grown on a field.

(13) That the test of growing intertilled crops in place of alternate fallowing has given some results that indicate the practicability of substituting potatoes and, possibly, corn.

MISCELLANEOUS CROP TESTS.

The experiments with crops other than grains have given some promising results. It has been demonstrated with reasonable certainty that forage crops, particularly alfalfa, can be profitably grown on the dry lands. The results obtained with these crops will now be briefly discussed.

Considerable of the work with forage crops has been conducted in cooperation with the Office of Forage-Crop Investigations of the Bureau of Plant Industry.

ALFALFA.

The substation has tested three varieties of alfalfa—Turkestan, sand lucern, and common Utah alfalfa. The Utah variety has usually given the best results, although very little difference was noticeable in the three varieties, either in vegetative habits or yield. The average yield of the Utah variety during the past six years has been about 3,000 pounds per acre in the first crop. The second crop has not produced enough forage to pay for cutting, but some pasturage has been furnished. Fall planting proved a failure. Planting in late April or early May has been very successful. A well-prepared seed bed is imperative, and when this is obtained it is advisable to plant as soon after a rain as the soil can be worked without puddling. If the seed bed is in the proper condition and good seed is used, 4 to 6 pounds of seed to the acre is sufficient, and it should be planted with a press drill. The use of oats or any other grass as a nurse crop is not advisable.

Spring harrowing is very effective in preventing the growth of cheat (June-grass) and other weeds, in destroying insect pests, and in conserving the soil moisture. If the ordinary harrow is followed with a brush harrow the lumps of soil which frequently are a disadvantage in cutting can be largely eliminated. The use of a disk harrow on the fields during the early spring every year or two has given good results.

The crop should be cut about June 15 ordinarily, depending on the moisture conditions and the crop's stage of maturity. Care should be taken to cut the crop before the plants shrink because of drought and before the plants become tough. The hay should be raked and piled immediately after cutting. If a buncher is attached to the mower excellent results are obtained. The hay can be placed in the barn or stack after it has cured for about three days.

Alfalfa seed.—Experiments in alfalfa-seed production are being conducted at the substation. The most promising results are being obtained from the alfalfa planted in rows and intertilled. These experiments have not been carried on long enough to warrant definite conclusions, but the results indicate that seed production is likely to become one of the most profitable dry-land industries. A great many difficulties are encountered in producing alfalfa seed, and it is the object of the experiments at the substation to find means of overcoming these obstacles.[a]

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[a] See Circular 24 of the Bureau of Plant Industry for a detailed discussion of the production of alfalfa seed in rows.

BROME-GRASS.

Brome-grass has proved fairly successful at Nephi. Because of the strong demand for seed the crop has not been cut for forage except on two plats in 1909. These plats were not planted until 1908, and hence the forage yield was small. It is thought that a yield of about 1,500 to 2,000 pounds to the acre can be expected after the first year and until the ground becomes sod bound. This is likely to occur in five or six years. The seed yields have ranged from 62½ to 300 pounds per acre. The average price obtained is about 20 cents a pound. The seed should be planted in May on a carefully prepared seed bed at the rate of 10 to 15 pounds per acre. It is well to plant just before a rain, if possible. The seed can be sown broadcast and be covered by a very light harrowing, or it can be planted with a drill. Deep planting should be avoided. About 1 inch is the desired depth to plant. The forage is relished by horses and cattle and the sod furnishes excellent pasture.

NURSERY WORK WITH GRASSES.

A number of perennial grasses are being tested in rows to determine whether this method of culture is practicable either for seed or hay. As they were not planted until 1909 no data for publication has yet been obtained.

FORAGE SORGHUMS.

In 1909 two varieties of forage sorghums, Minnesota Amber and Red Amber, were tried. A good growth was made during the late summer, but a frost on September 11 prevented the plants from maturing and destroyed their forage value. They yielded 2,490 pounds and 2,840 pounds per acre of dry material respectively. Whether these crops will be profitable for the dry lands can not be definitely known until the test is carried on for a few years longer. It is probable that the early frosts occurring in the high altitudes will prove a deterrent to their successful production.

PEAS.

Only preliminary work with peas has been done at the substation. The results with one variety, a Canada pea obtained from Colorado, indicate that the crop may become profitable, but further work must be done before this can be known definitely. In addition to this variety several varieties of Canada peas and of grass peas have been tested in rows. So far none has produced a profitable yield. If varieties can be secured that are adapted to the dry conditions obtaining in the mountain areas it is quite probable that peas will prove a valuable dry-land crop, both for forage purposes and for increasing soil fertility.

CORN.

Corn has been tested at Nephi for six years. The flint varieties have done considerably better than the dents, but neither has given very promising results. It will be necessary to do a great deal of adaptation and improvement work before a strain that will succeed under the local conditions can be developed. Cool summer nights and early autumn frosts, as well as the heavy soil, seem to oppose the successful growth of corn at the substation. Some success has been had by farmers on the foothills and benches near Nephi and in other parts of Utah where the soil is sandy or gravelly, but on heavy clay soils, similar to those at the substation, corn is not as yet a dependable crop.

POTATOES.

The results of the work with potatoes have been very encouraging. They are grown after wheat in substitution for alternate fallowing. In 1909 a yield of 85 bushels of excellent potatoes was obtained. In the variety tests on soil fallowed in 1908 even better yields were obtained, the average of 12 varieties being 100⅖ bushels per acre. The White Peerless and the Irish Cobbler are the most desirable varieties of those tested. The former produced at the rate of 98 bushels per acre and the latter at the rate of 112 bushels per acre in 1909. The average cash value per acre in 1908 and 1909 of the varieties tested was approximately $22. Tests conducted in 1909 favored planting the tubers about 8 inches deep in rows 3 feet apart, with the hills 2 feet apart in the rows. Potatoes grown on dry land in 1908 produced better results in 1909 than those grown on irrigated land. Potatoes as a dry-land crop, especially as a substitute for alternate fallowing and as a crop to be grown on small fields inconvenient for grain production, are very strongly recommended.

SUGAR BEETS.

Variety tests with sugar beets were made in 1908 and 1909 in cooperation with the Office of Sugar-Plant Investigations of the Bureau of Plant Industry. In 1908 a disease commonly called "root-rot" destroyed the crop. In 1909 the average yield was only 3,944 pounds per acre. The production of beets on the very dry lands is scarcely likely to become profitable unless it be tried for the purpose of producing small quantities of stock feed. Farmers are advised not to plant beets on their dry lands unless it be on a small scale until they find that they can raise profitable yields under their particular conditions.

MISCELLANEOUS DATA.

NURSERY WORK.

The nursery work at the substation at Nephi, Utah, consists principally of three classes of tests: (1) The trying out of a large number of varieties and strains of crops the seed of which has been obtained from foreign countries and from different parts of the United States. This seed is planted in rows and grown for the purpose of studying the behavior of the plants under the conditions existing at Nephi and of determining whether or not the crop or variety is adapted or adaptable to the dry-land conditions. (2) The testing of plant selections made from the crops on the substation plats. This includes the determination of superior plants and the purification of varieties through the separation of types. Superior strains discovered in the nursery will be increased and tested in the plats under actual field conditions, and the seed of the best will ultimately be distributed to the farmers. (3) Miscellaneous experiments (tests of different sizes of seed, treatment of seed for smut prevention, etc.).

The nursery work was not started until the spring of 1908 and so far only preliminary results have been obtained. These have been extremely encouraging, but it is thought that their publication at this time is unwarranted. For this reason only a numerical summary of the work under way is given in Table X.

TABLE X.—*Number and character of tests of various crops, conducted in the nursery at Nephi, Utah, during 1909.*

Crop.	Number of tests in 1909.			
	Selections.	Introductions.	Miscellaneous.	Total.
Winter grains	196	30	20	246
Spring grains (including grain sorghums)	193	29	82	304
Alfalfa		96		96
Peas		14		14
Perennial grasses		13		13
	389	182	102	673

In the fall of 1909 the nursery work with winter grains was very much increased, and most of the nursery work with grain will hereafter be confined to the winter varieties, as these, as shown earlier in these pages, are of greater importance than the spring varieties in the Mountain States.

NUMERICAL SUMMARY OF CROP EXPERIMENTS.

To give an idea of the volume of the work of the substation the following numerical summary of all the crop experiments being conducted is presented in Table XI.

TABLE XI.—*Number and character of all tests of crops conducted at Nephi, Utah, during 1909.*

Crop.	Number of tests in 1909.		
	Tenth-acre and fifth-acre plats.	Rows.	Total.
Winter grains	113	246	359
Spring grains	29	304	333
Forage crops	30	124	154
Potatoes	3	29	32
	175	703	878

SOIL-MOISTURE INVESTIGATIONS.

Some very important work that is not included in the foregoing summary is the work done in investigating the behavior of the soil moisture under the various treatments applied to the soil. The work is closely allied to that done in connection with weather phenomena, discussed at the beginning of this report. Both are conducted in cooperation with the Physical Laboratory of the Bureau of Plant Industry, the apparatus used being furnished by the laboratory. In 1909 moisture studies were made on 29 plats under different treatments. Each plat was sampled to a depth of at least 6 feet and 5 plats to a depth of 10 feet, the moisture being determined in the soil of each foot. Determinations were made on 942 samples during the season. This work will be of great assistance in determining the best crops to grow and how to grow them.

EXPERIMENTAL CISTERN.

The problem of supplying water for domestic use is a serious one on the dry lands. It is not uncommon in the Mountain States for farmers to have to haul water from 2 to 10 miles for their live stock. This is a great expense, and if it can be eliminated the dry-land farmer will be very much benefited. In 1909 the Physical Laboratory installed at the substation a cement underground cistern having a capacity of about 800 cubic feet. The roofs of the substation buildings were guttered so that the rain water falling on them is carried into the cistern. It is thought that the practicability of conserving the water that falls on the roofs can be demonstrated by this experiment. The plan has attracted considerable attention among the farmers operating near the substation, and it is confidently expected that some valuable information in connection with this important problem will be gained.

SEED DISTRIBUTION.

One very important benefit derived from the cooperative work is the distribution of pure seed of superior varieties tried and developed at the substation. Since the 1908 harvest, seed has been sent in quantities varying from 1 pound to 1 bushel to about a hundred farmers and experimenters in Utah, Arizona, South Dakota, Montana, Oregon, Idaho, Wyoming, Nevada, Nebraska, Washington, Colorado, New Mexico, and Australia. In addition to the seed distributed by the substation directly, a large quantity is distributed by reliable farmers who have obtained their start of seed from the substation, or by others whose methods are known to be reliable. In this way the cooperators are instrumental in a wider seed distribution than is shown by the above enumeration. Ordinarily the seed is sold to the farmers who wish to try it. It has been found that this method produces better results than can be obtained by making a free and indiscriminate distribution.

COST OF WHEAT PRODUCTION ON THE DRY LANDS.

In order to be able to present some figures on the cost of producing an acre of dry-land wheat, itemized statements of expense were obtained from the farmers named below. These farmers are successful and each practices the best farming methods in vogue in his particular locality.

Cost on old land.—The figures given in Table XII represent the cost of producing an acre of wheat on old land and include all the operations from plowing the stubble land to harvesting and thrashing the crop. The Grace Brothers have included the cost of marketing.

TABLE XII.—*Cost of producing an acre of wheat and average yield on old land in Utah.*

Name and address of farmer reporting.	Average yield per acre.	Cost per acre.
	Bushels.	
Grace Brothers, Nephi, Utah	30.0	$5.60
James Jensen, Collinston, Utah	25.0	5.47
Peter Peterson, Petersboro, Utah	24.6	5.96
John Q. Adams, Logan, Utah	27.0	5.35
Average	26.65	5.59

If the work is all done under contract the cost would probably be anywhere from 20 to 40 per cent more than the figures presented in Table XII, depending on the supply of labor available. The detailed figures submitted by the farmers named have been averaged and arranged in a roughly itemized form, as presented below:

Plowing	$1.22
Care of fallow, including all work between plowing and planting	.90
Seed	.57
Planting	.35
Harvesting and thrashing	2.55
	5.59

The variations of detail in the methods practiced by the farmers consulted were of such a nature that it was not possible to make a more fully itemized statement than the one presented. There were wide variations in the cost of each operation due to differences in local conditions, but, as previously shown, the cost per acre to each farmer was very near the cost to each other farmer. It is believed that in most cases the farmer can safely depend on producing an acre of wheat on old land for $6, when he uses his own horses and machinery, and for from $7 to $10 when the work is all under contract.

Cost on new land.—The conditions existing on unbroken land vary so widely that nothing more than a very rough estimate of the cost of producing the first crop can be given. The expense will vary with the nature and quantity of native vegetation to be removed, the time at which the clearing and plowing are done, the character of the soil, the supply of labor, etc. In Utah the clearing and plowing of sagebrush land costs, when done under contract, from $4 to $7 per acre. The care of the plowed soil and preparation of the seed bed ordinarily cost somewhat more than the same work on old land. Planting, harvesting, and thrashing cost, of course, the same as on old land. It is doubtful whether an acre of wheat on new land will cost, under any common conditions, more than $12. The average is about $10 an acre.

PROFITS IN WHEAT PRODUCTION.

As previously shown, the average yield obtained by the four farmers quoted in Table XII was 26.65 bushels per acre. There is little doubt that this yield can be produced generally in the average sections of the Mountain States if the very best farming methods are practiced. For a farmer who expects to begin operations in this region, however, it is safer to estimate the yield at not more than 20 bushels per acre. With wheat at 75 cents a bushel then, the following figures showing the net profit derived from an acre of wheat on old land are considered conservative:

Twenty bushels at 75 cents	$15.00
Cost of production (including 3 cents a bushel for marketing)	6.60
Net profit	8.40

A net profit of $8.40 per acre can reasonably be expected on land that has been fallow one year previous to cropping. This amount earned every other year is equal to 10 per cent interest on an investment of $42 per acre for the land. Whether the farmer will actually gain $8.40 on each acre producing wheat will depend not only on local conditions and prices but also to a very great extent on his ability to minimize expense and maximize yields. A slight saving of expense per acre or a small increase in yield per acre will materially increase the profits of the farm. The greatest economy is necessary in order to prevent waste of time, money, and product. The farmer who gives his land approximately as much careful attention as the successful business man devotes to his business, and who exercises the same degree of thoughtfulness in planning and carrying on his operations, will find dry-land grain production a reasonably profitable vocation.

Approved:
James Wilson,
Secretary of Agriculture.

Washington, D. C., *April 4, 1909.*

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